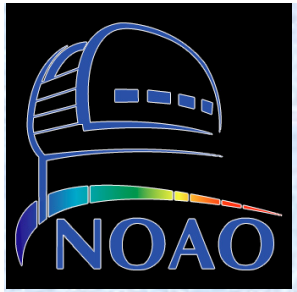
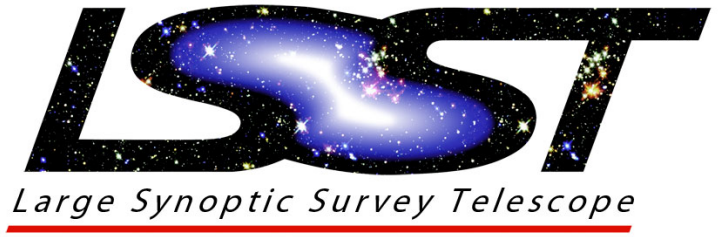




Modeling Survey Strategy – the Operations Simulator

Steve Ridgway, NOAO

Dark Energy Science Collaboration
Pittsburgh, December 4-6, 2013

The Operations Simulator…..

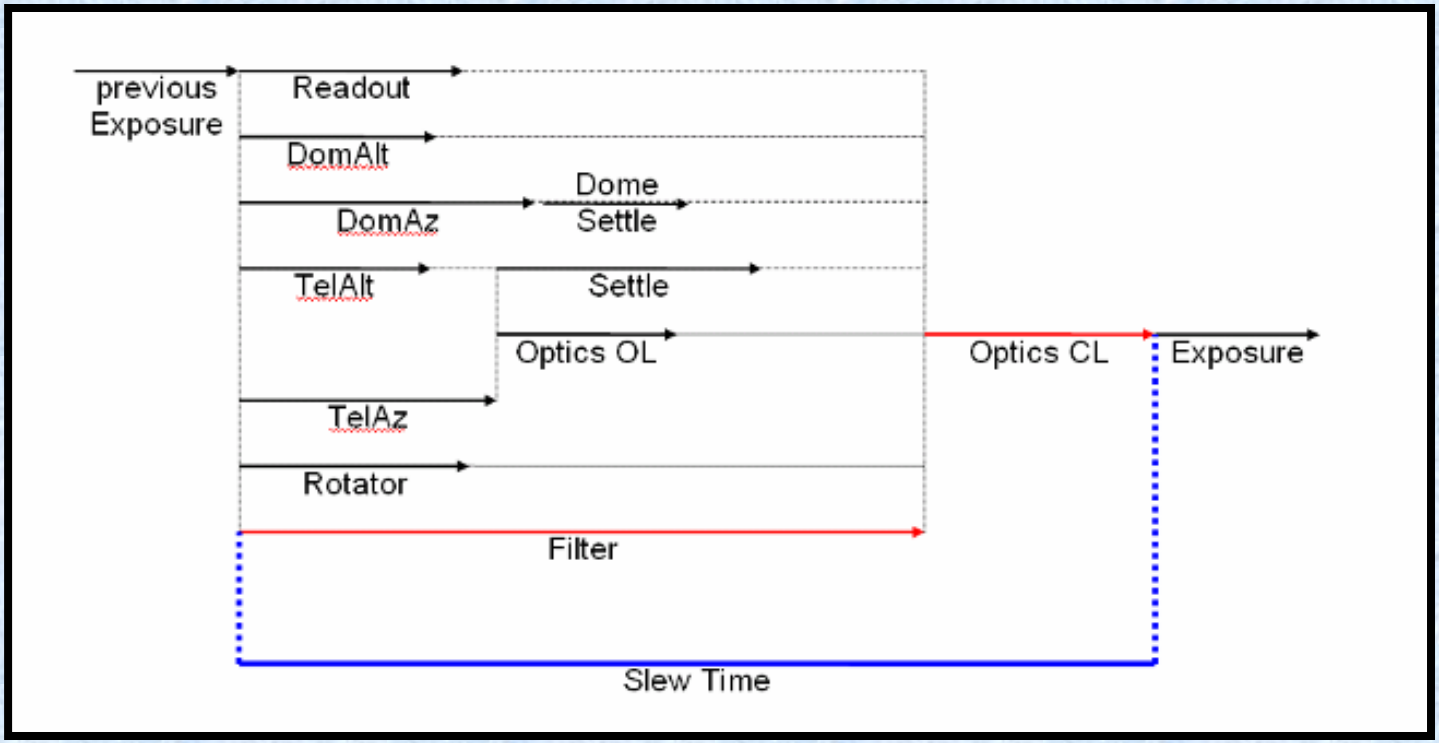
- Generates 10-year observing programs (2.5M observations)
- Accurately models telescope design performance
- Represents weather, atmosphere and sky with models and archival data
- Delivers an image list with associated measures of quality

and is used for…..

- *Telescope/survey dimensioning*
- *Site evaluation*
- Engineering tradeoffs
- Survey performance prediction
- Science performance optimization

How OpSim Works

- Identify the highest priority field for the next visit
  - Based on – Cost/Benefit
  - Cost ~ shutter closed time between targets
  - Benefit empirically adjusted per program element



Example Requirements for a Simulation

Sensitivity-based requirements

- Single-visit depth
  - Aperture/throughput/seeing/detector/integration time
- Total visits/stacked depth
  - Efficiency/weather/down-time/

Cadence-based requirements

- Asteroid detection/tracking
- Supernova discovery/characterization
- Astrometric performance

Uniformity requirements

- Early coverage (photometry closure/reference images)
- Stacked coverage (depth/image quality)

Example Requirements for a Simulation

Sensitivity-based requirements

- Single-visit depth
  - Aperture/throughput/seeing/detector/integration time
- Total visits/stacked depth
  - Efficiency/weather/down-time/

Cadence-based requirements

- Asteroid detection/tracking
- Supernova discovery/characterization
- Astrometric performance

Uniformity requirements

- Early coverage (photometry closure/reference images)
- Stacked coverage (depth/image quality)

What OpSim Produces

- **A chronological list of 2.4-2.6 million visits**
- **77% open shutter time - 96.8% of maximum theoretical efficiency**
- **~50 parameters per visit**
  - Field/filter/seeing/sky-bright/cloud/airmass/etc
- **Tracking of engineering data**
  - Times for slew/dome/rotator/filterchange/camera-rotator
  - Contribution of engineering functions to critical path
- **More than 500 survey simulations of length 3 or 10 years**

Post-processing of Simulations

- Single visit and stacked visit statistics -SSTAR
- Cadence-based performance – Metrics

Sky Coverage Exceeds SRD Requirements

OpSim reference simulation 3.61

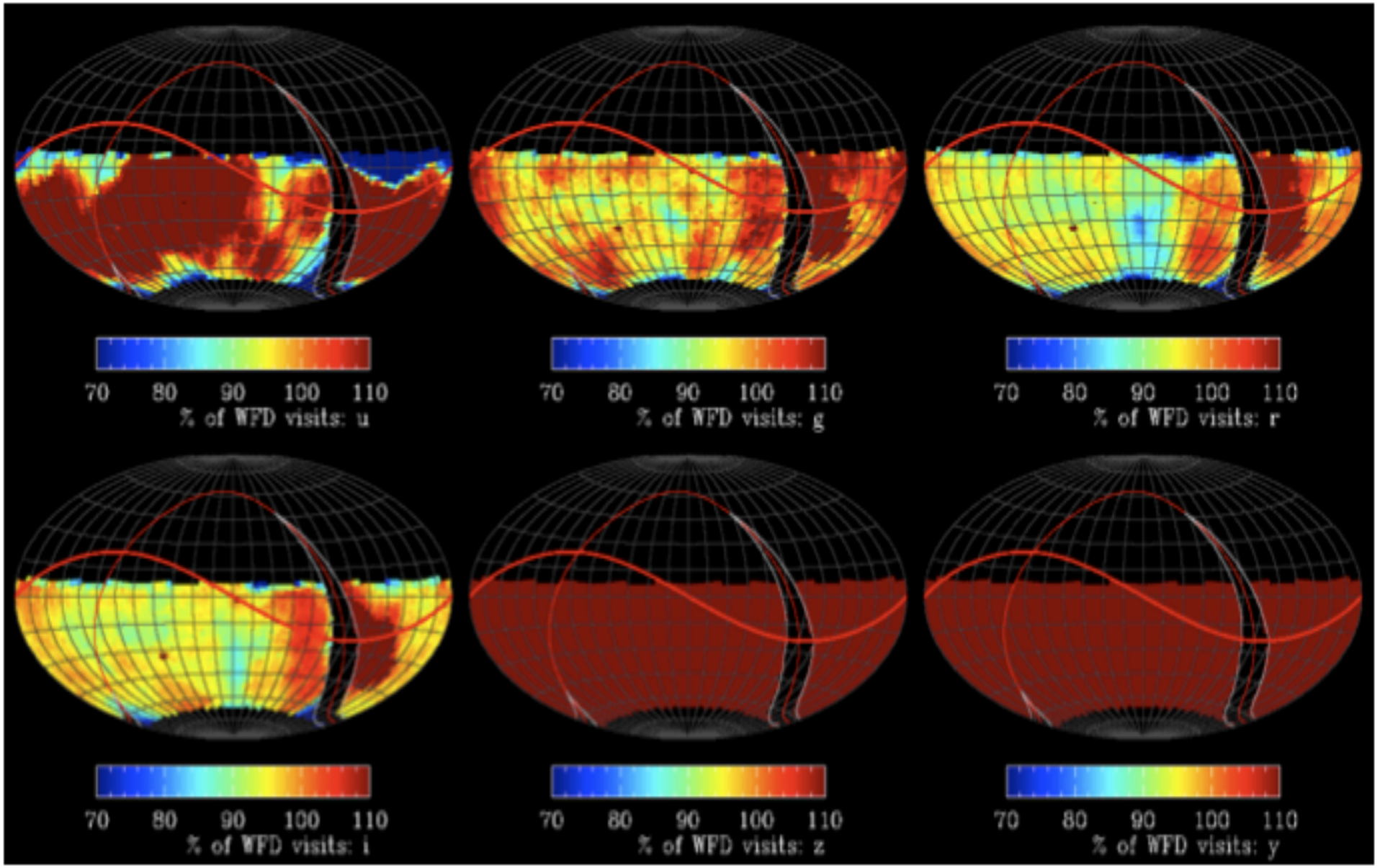
- sky coverage at the SRD stretch goal of 20,000 degrees^2
- 887 visits per WFD field
- Median coadded depth in *all* fields validates Design depth prescribed for the main survey.

8% margin over Design spec

11% margin over Design spec

But……

Visits per Field / Required – WFD only



Merit Functions and Metrics

- Merit Functions are post-processing algorithms which characterize science-oriented and mostly cadence-related performance.
- There are currently 21 groups of Merit Functions in the areas of:

Astrometry
Image quality
Uniformity of distribution in time
Early sky coverage
SN sampling
Periodic variable sampling
Sampling gaps
Randomization of optics axes on sky

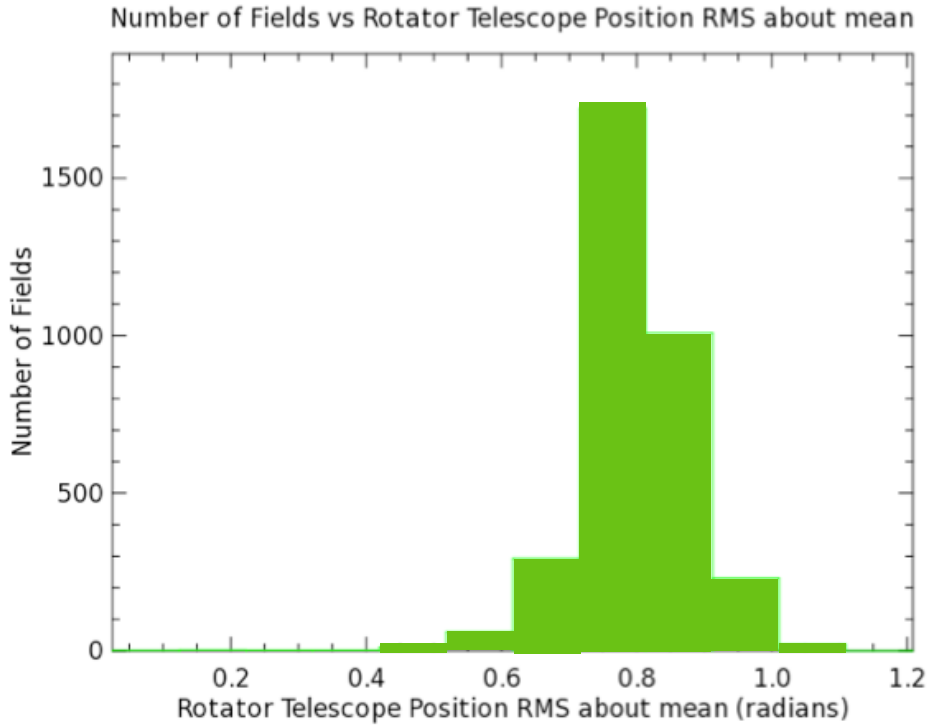
Merit Functions and Metrics

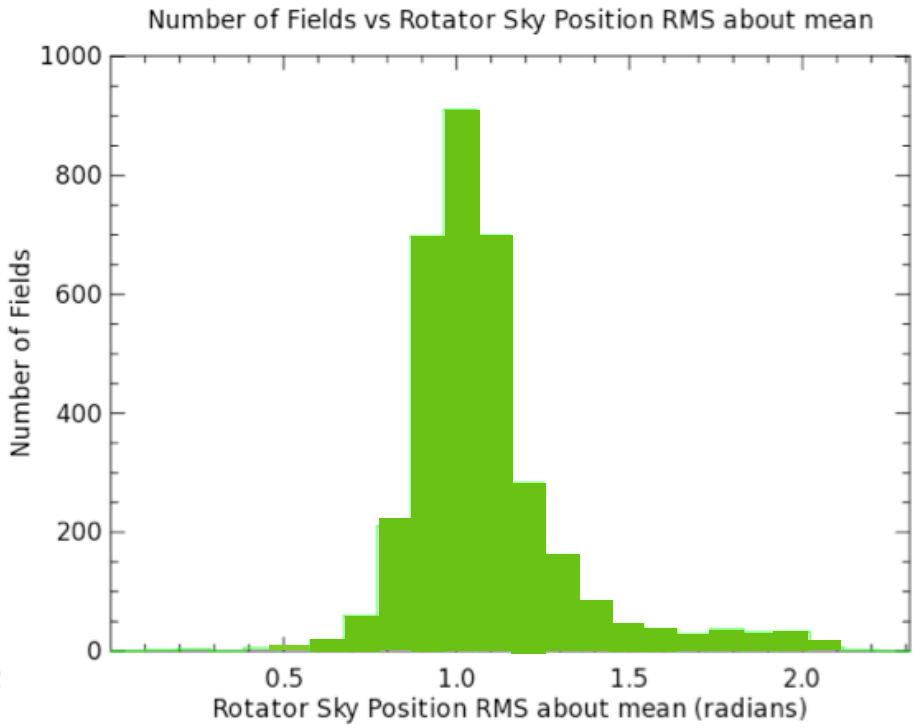
- Merit Functions are post-processing algorithms which characterize science-oriented and mostly cadence-related performance.
- There are currently 21 groups of Merit Functions in the areas of:

Astrometry
Image quality
Uniformity of distribution in time
Early sky coverage
SN sampling
Periodic variable sampling
Sampling gaps
Randomization of optics axes on sky

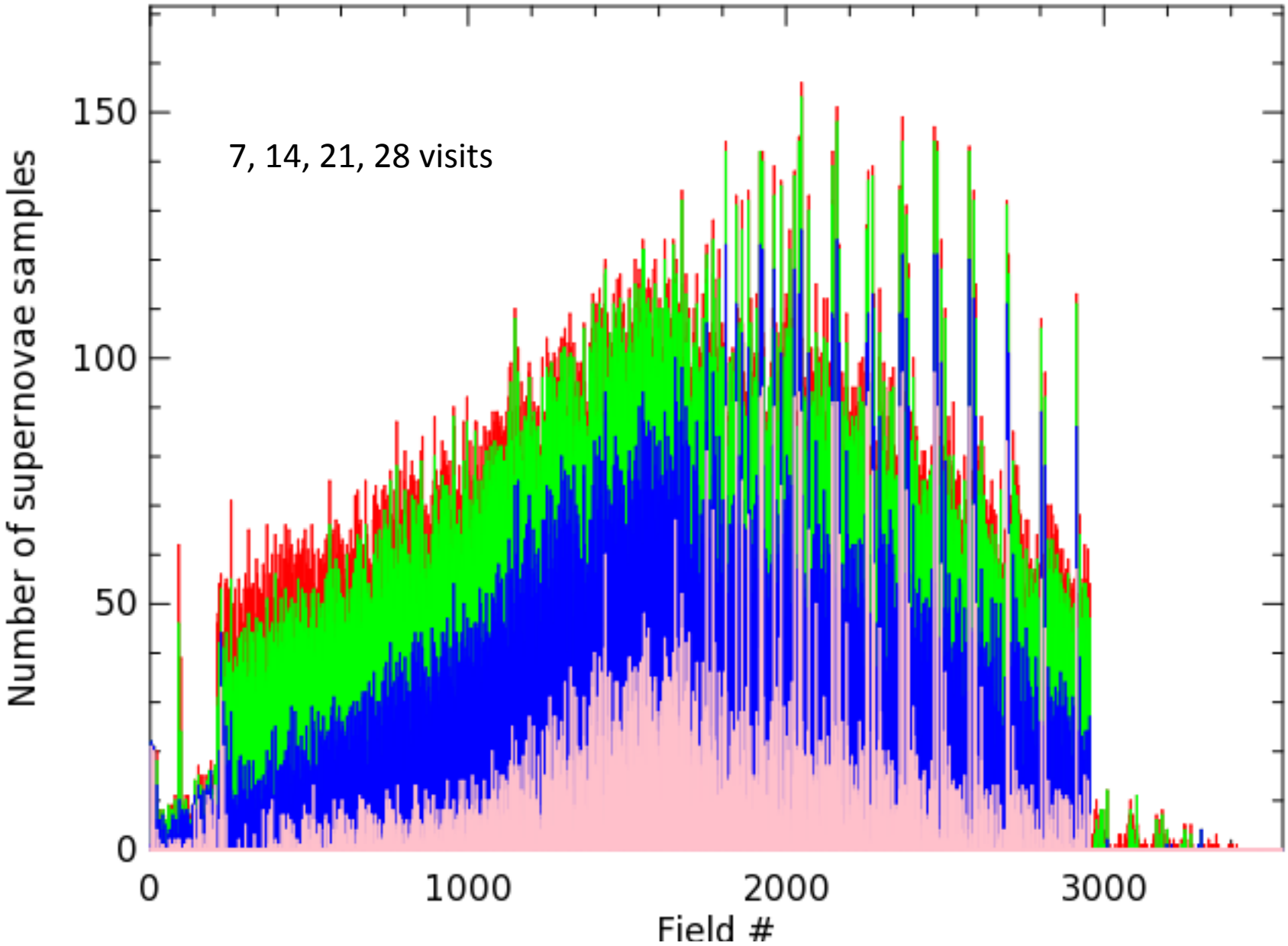
Rotator Angles

In order to control image shape systematics, it is important that the azimuthal angles of the camera and telescope optics, projected on the sky, should be well randomized. The figures below show that most fields have RMS rotator values near 1 radian (random) and very few have low RMS. Techniques are available for further improving randomization if needed.

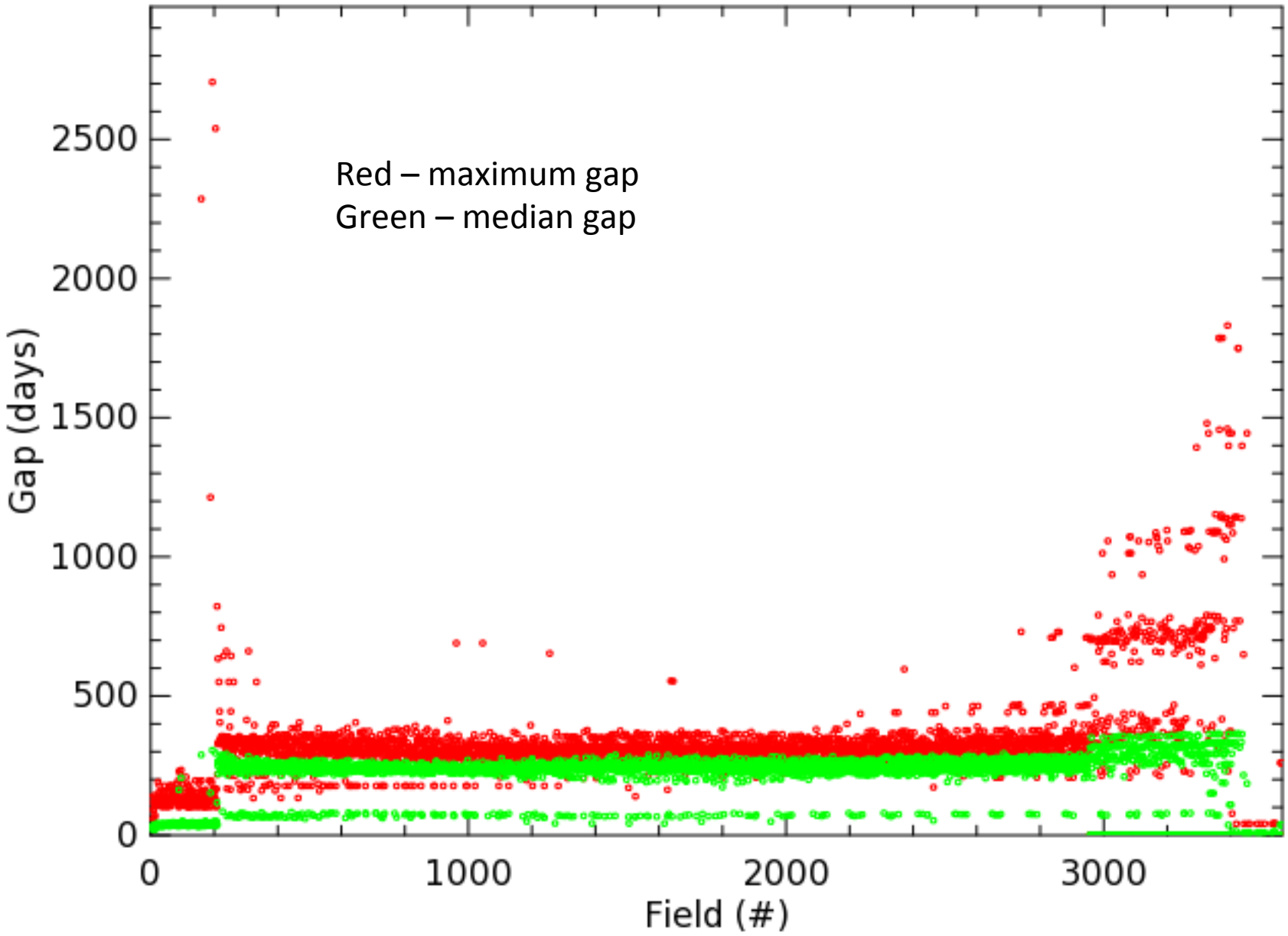




Supernovae Discovery and Sampling



Seasonal Sampling Gaps per Field in i



Some lessons learned

High efficiency can be achieved with OpSim

Efficiency trades against uniformity

SRD does not strongly constrain cadence – there is considerable room for optimization of science performance and efficiency

Strong optimization for Asteroid/NEO science does not compromise other SRD priorities

Performance for sampling of periodic variables and slow transients is excellent

Rapid and multi-color sampling of fast transients is achieved with dedicated cadence (deep drilling)

On-going OpSim Development

- OpSim 3.0
  - Look ahead
  - Complex sequences
  - Algorithm experimentation
- Other simulation improvements
  - Sky brightness and cloud models
- Metric Development and Post-processing framework
  - Insight into schedule performance
  - Broader access

OpSim Challenges

- Scheduling algorithms and optimization
- Expert contribution to metrics specification and development